

NATIONAL ICE CENTER/NAVAL ICE CENTER SUPPORT TO SUBMARINE OPERATIONS

by CDR Zdenka Willis, USN,
CDR Michael Foster, USN,
Ms. Cheryl Bertoia, and LT Kyle Dedrick, USN

The world has changed considerably since USS *Nautilus* (SSN-571) made history in 1958 by completing the first trans-Arctic voyage beneath the polar ice cap. Now that the Navy has firmly established that it can conduct these operations routinely, our focus today is largely on maintaining presence in that strategic area and fully exploiting the environmental information that submarines gather while they transit beneath the Arctic ice. In a recent message, the Commander, Submarine Forces, U.S. Atlantic Fleet (COMSUBLANT) emphasized the importance of a thorough understanding of ice conditions to submarine operations:

"Accurate knowledge of the marginal ice zone (MIZ) and pack ice location is essential for continuing submarine operations in the Arctic. Submarines operate in the vicinity of the sea ice for a variety of missions spanning cooperative scientific research to theater and national operational tasking. Arctic operations remain a key component of the submarine force's flexibility to operate anywhere, anytime."

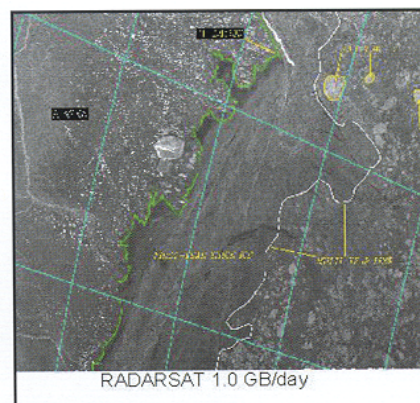
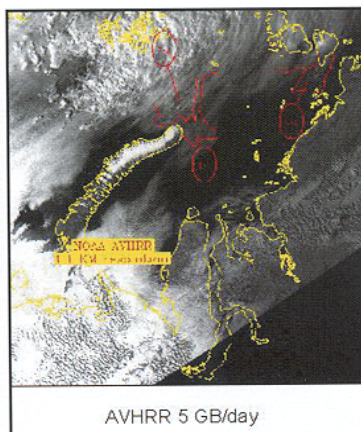
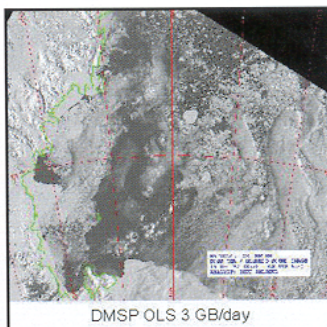
With our current capabilities to monitor sea ice using aircraft and imaging satellites, the data that submarines bring back from beneath the surface is a valuable adjunct for characterizing environmental conditions in the Arctic region. Thus, for tracking and analyzing sea ice – its growth, recession, and motion – there is probably no more fruitful partnership than the teaming of Navy's Arctic-going submarines and the National/Naval Ice Center in Washington, DC.

NATIONAL ICE CENTER COMPONENTS – AND A VARIED CUSTOMER BASE

The National Ice Center (NIC) is a unique interagency organization with oversight from the Departments of Defense (DoD), Commerce (DoC), and Transportation (DoT), and it serves both Defense and U.S. national interests. The Naval Ice Center (NAVICE) is the largest component of NIC, and it reports to the Naval Meteorology and Oceanography Command through the Naval Oceanographic Office. The Commanding Officer of NAVICE is also the Director of NIC. DoC representation is provided by the National Oceanic and Atmospheric Administration's (NOAA) Office of Satellite Data Processing and Distribution, and the DoT leg of the triad is supplied by the U.S. Coast Guard's (USCG) Director of Operations Policy. The Center, located at the Federal Census complex in Suitland, Maryland, employs 63 Navy military and civilian personnel, eight NOAA civilians, and a Coast Guard petty officer.

NIC's mission is to provide high-quality, worldwide analyses and forecasts of ice cover, thickness, density, and movement to the DoD and other U.S. agencies. If there's ice in the water – from the Arctic, to the Antarctic, or anywhere in between – including Baffin Bay, the Great Lakes, Chesapeake and Delaware Bays, the Sea of Japan and the Yellow Sea – NIC will be able to tell you about it. The Center's customer base includes operational and research communities within DoD and other government bodies, foreign operational and research organizations, and the general public. However, NIC's primary DoD customer is the Submarine Force.

NIC supports every submarine mission under the ice and operations in and near the Marginal Ice Zone. The NIC staff is committed to ensuring safe operations in, around, and beneath ice-covered waters,



*Typical data
sources for ice
analysis.*

and they work directly with COMSUBLANT, COMSUBPAC and the Operational Support Division (N23) within the Office of Chief of Naval Operations (CNO) to provide timely characterization of ice conditions worldwide. Normally, this information is formatted for transmission to submarines at sea on the very low frequency (VLF) broadcast, but several other alternatives exist. Historically, NIC has supported all such operations as the submarine under-ice science expeditions (SCICEXs) that concluded in 1999 with USS *Hawkbill's* (SSN-666) final deployment. This required providing pre-deployment packages, day-to-day products, and ice reconnaissance personnel on site at the associated ice camps. With the decommissioning of the last ice-strengthened submarine, the data provided by NIC becomes much more important to submarines operating in the vicinity of ice cover, as the criteria for operating safely become more stringent.

Additional interest in the Arctic has also been stimulated by the launch of the new U.S. Coast Guard icebreaker USCGC *Healy* (WABG-20), whose primary mission will be support of Arctic science. This represents a fundamental shift in the Coast Guard's Arctic emphasis, from logistics – breaking ice to re-supply remote, high latitude stations – to sharing in both operational and research commitments in that region.

DATA GATHERING AND ANALYSIS

As technology advances, so do NIC's capabilities. Prior to the launch of the first operational meteorological satellites, the Center relied heavily on aerial ice reconnaissance and in situ reports from ship captains. In the late 1980's, satellite imagery first became available at NIC, but initially, most of the data was 24 to 48 hours old. In 1994, NIC began to receive satellite data routinely on a near-real-time basis – within six hours of image acquisition – and this capability has resulted in a decided shift from aerial reconnaissance to

satellites as the primary source of data for ice analysis and forecasting. Currently, NIC receives over 9 Gigabytes (GB) of digital data every day to support its operations.

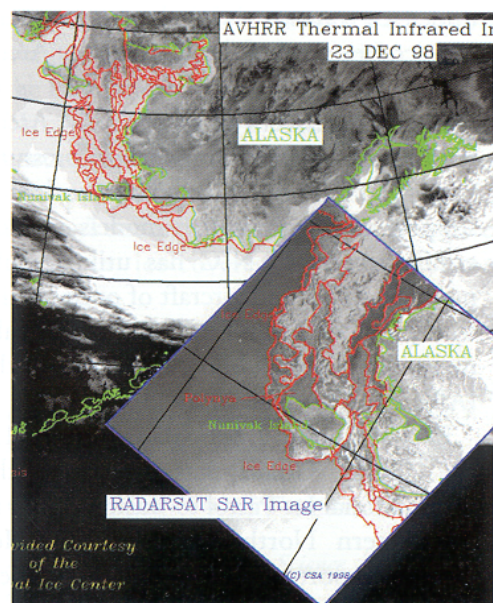
The steadily increasing quality of satellite data over the years has greatly facilitated the production of more accurate and timely products. Traditional visible and infrared satellite images from the Operational Line Scan (OLS) sensors of the Defense Meteorological Satellite Program (DMSP) and from the Advanced Very High Resolution Radiometer (AVHRR) aboard NOAA's Polar-Orbiting Environmental Satellites (POES) are excellent data sources when the Arctic/Antarctic regions are not cloud covered (about 30% of the time). To mitigate the effect of clouds, NIC also uses spaceborne passive and active microwave sensors, such as the passive Special Sensor Microwave/Imager (SSM/I), which provides maps of sea ice concentration. While SSM/I's coarse resolution (25km) and ambiguity about thin ice cause some problems in identifying the ice edge, it provides reliable global coverage independent of weather conditions and the lack of solar illumination during the months-long polar night. After several years of successfully using SSM/I, NIC now gets even better observations in the microwave region with active, synthetic-aperture radar (SAR) imagery from the Canadian RADARSAT-1 SAR satellite. RADARSAT-1 is the world's first radar satellite specifically designed for operational sea ice monitoring, and NIC began extensive use of its data just after its launch in 1995.

OPERATIONAL ICE CHARTS AND OTHER PRODUCTS

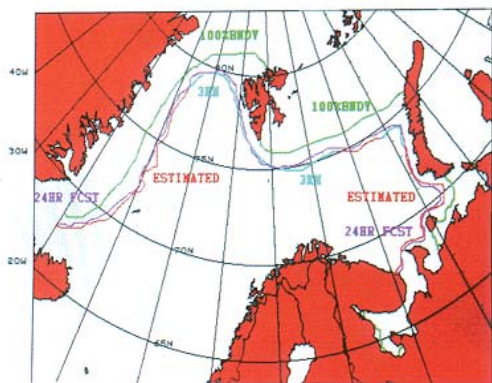
NIC's global and regional sea ice analyses are available on the World Wide Web in two formats: (1) GIF and TIFF image files using the World Meteorological Organization's (WMO) Ice Egg Code; and (2) Geographic Information System (GIS) Vector files,

which can be viewed and manipulated using ARCEXPLOER, a software package freely available from the Environmental Systems Research Institute (ESRI). Also, some of the Center's products are transmitted as text messages.

NIC produces two specialized messages for underway submarines. In SUBLANT's area of responsibility (AOR), the message is called the Special Arctic Oceanographic Synopsis (SPAROS), and in SUBPAC's AOR, the corresponding product is referred to simply as the Ice Hazard message. Both of these are in the OTH-Gold format and describe the 100 percent ice concentration boundary, the analyzed ice edge, and a 24-hour ice-edge forecast. RADARSAT is the sensor of choice for creating these products, because it yields all-weather images with 100-meter spatial resolution. Whenever possible, NIC also incorporates DMSP data with a resolution of 550 meters, but clouds often obscure the ice. The SPAROS/Ice Hazard products can be viewed on the Global Command and Control System-Maritime (GCCS-M) or any other system that can display the OTH-Gold messages.



RADARSAT brings high resolution and all-weather coverage to the process.



SPAROS/ICEHAZARD (left) and FLAP (right) products

On the tactical scale, NIC provides a Fractures/Leads and Polynyas (FLAP) product and annotated imagery. (Leads are navigable passageways through sea ice, whereas polynyas are "islands" of thin ice or open water surrounded by solid ice cover.) FLAP is also an OTH-Gold formatted message and identifies surfaceable features in the ice over large areas. Annotated satellite images are provided for non-routine, special operations or exercises and are very popular with many of NIC's customers. Bandwidth limitations preclude sending annotated images directly to submarines at sea, but shore staffs use them routinely for planning purposes.

NIC still retains an ice reconnaissance capability to support both DoD and Coast Guard missions. This has been useful in both SCICEX operations and submarine under-ice transits. NIC also manages the U.S. component of the Interagency Arctic Buoy Program (IABP), whose goal is to maintain a network of buoys in the Arctic to measure surface atmospheric pressure, surface air temperature, and sea-ice drift in support of global weather models and scientific research. NIC has utilized submarines, ships, and aircraft of opportunity to deploy buoys, and in fact, the last submarine to launch a buoy in support of the IABP was Hawkbill in 1999.

Ever since the *Titanic* disaster in 1912, the Coast Guard has operated the International Ice Patrol to track icebergs in the eastern North Atlantic. The Ice Center supports this effort and other operational missions by evaluating a variety of national imagery. Similarly, although it is not an official mission, NIC has been tracking icebergs in the Antarctic region

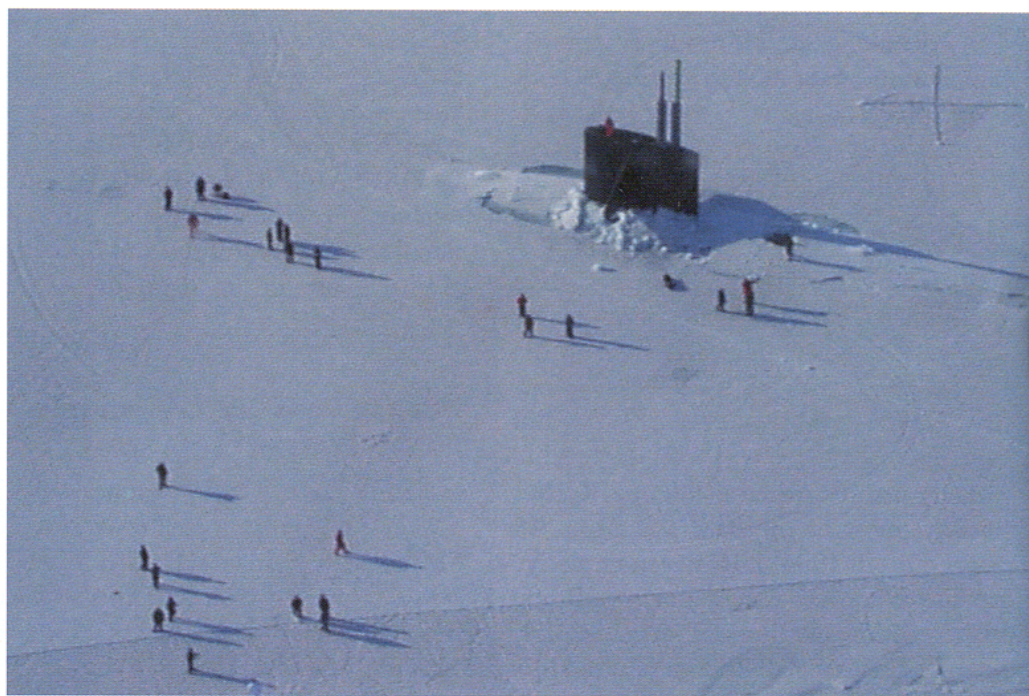
for 24 years. Last year the movement of a 24 by 48 nm iceberg into the shipping lanes south of Argentina caused sufficient danger to ships and submarines that many had to be diverted from their planned courses.

CHANGING PRODUCTS TO MATCH CUSTOMER'S NEEDS

The Ice Center's products are gradually shifting from static images to interactive displays presented in a true GIS format. This summer, a 22-year digital time series of high-resolution ice analyses covering the entire Arctic will become available. This Sea Ice Atlas will contain over 1,200 weekly ice analyses and a monthly sea-ice climatology derived from national technical means and produced under the auspices of the U.S./Russia Environmental



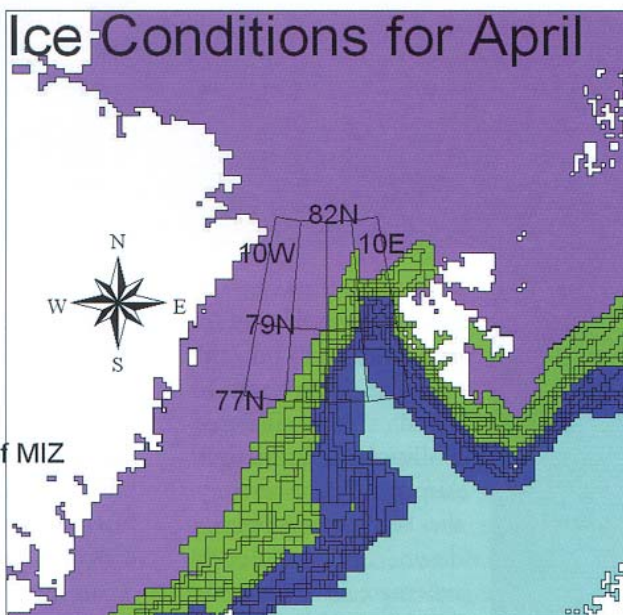
Annotated RADARSAT image supporting ASL's base camp for USS Hawkbill's surfacing at the North Pole



Aerial view of USS Hawkbill surfaced in a 600-foot wide refrozen lead.

Expected Ice Conditions for April

- Ice Free
- Maximum Extent of MIZ
- See Note 1
- See Note 2



Note 1: Out of 19 yearly observations, at least 9 indicate MIZ.

Note 2: 19 of 19 observations indicate ice.

Location of the ice edge and Marginal Ice Zone is necessary for mission planning.

Working Group. It will contain both U.S. and Russian Arctic data and appear in a CD-ROM format. In the future, NIC will be seeking to incorporate ice data into the Electronic Charting Display and Information System-Navy (ECDIS-N) for shipboard navigation.

Several impending changes in DoD policy will cause significant repercussions for NIC's future operating capabilities. As DoD relies increasingly on commercial satellite imagery as primary data for creating operational products, NIC will be challenged to retain affordable access to space sensor outputs. Although the current Canada-U.S. Memorandum of Understanding (MOU) that governs NIC's use of RADARSAT was just renewed, commercial entities will still seek opportunities to sell this data at market

rates. Thus, paying for this and similar environmental data will soon become a regular cost of doing business. This represents a fundamental paradigm shift, and DoD may need to redirect funding to assure continued access to satellite data. Meanwhile, NIC continues to evaluate other information sources to ensure that we can continue to accomplish our mission.

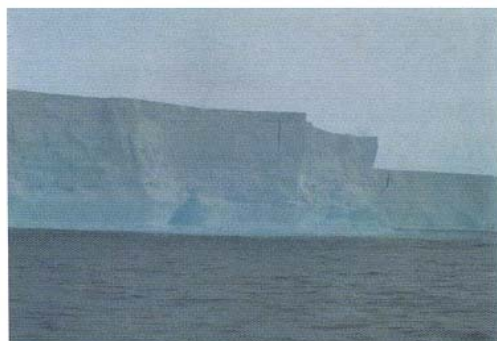
SCIENCE EFFORTS

In addition to its operational arm, NIC has recently established a mission-driven science team that allows the organization to participate in a broad spectrum of national and international arenas to explore new sensors, algorithms, and models to improve the ice analysis process. The NIC science team's primary function is to develop and

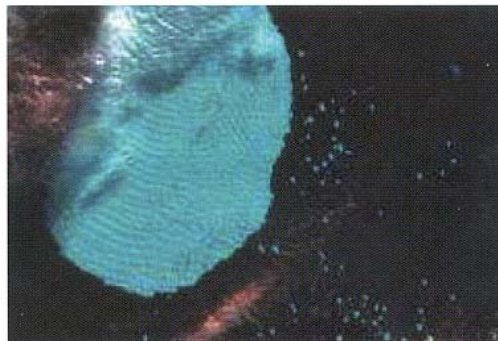
transition new techniques for enhancing the Center's effectiveness in carrying out its mission. One project expected to transition to the watch floor in the near future is ARKTOS, an intelligent classifier of SAR imagery, which combines image processing and artificial intelligence techniques to classify sea ice types. Another promising development is an algorithm to identify sea ice in the imagery available from the QuikScat microwave scatterometer installed on a recently launched National Aeronautics and Space Administration (NASA) satellite.

SUMMARY

The National and Naval Ice Center strives continually to satisfy new requirements posed by the changing missions of the Navy, NOAA, and the Coast Guard. As long as operators still depend on accurate sea-ice information to plan and execute missions safely, NIC will continue to pursue the best sources of environmental data and the most advanced data analysis techniques to improve the efficiency of its operations and the accuracy of its products. While sensors and technology have changed, one constant remains: After 40 years, NIC's single-minded dedication to observing and analyzing the planet's ice conditions still results in the most comprehensive global sea ice record available anywhere in the world. And for the foreseeable future, the National and Naval Ice Center will remain on watch to ensure that U.S. submarines and those of our partners are able to support the Nation's strategic interests safely and effectively in ice-covered waters, anytime, anywhere...



Iceberg B-10A, the size of Delaware, poses danger to shipping lanes.



CDR Willis is the Commander, National/Naval Ice Center.

CDR Foster is the Center's Executive Officer.

Ms. Bertoia is the Director, Science and Information Services.

LT Dedrick is the Center's Operations Officer.